

# PROBABILISTIC CHARACTERIZATION AND CLASSIFICATION OF EDGE-LOCALIZED MODE DYNAMICS IN THE JET TOKAMAK

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## Abstract

We consider classification of probability distributions modeling the dynamics of different types of instabilities, called *edge-localized modes*, in magnetically confined fusion plasmas. If not controlled or mitigated, the energy released in large type I ELM bursts could pose a threat to various plasma-facing material components in future fusion devices, such as ITER. Most ELM studies are based on average properties calculated over multiple ELM bursts, including inter-ELM time (inverse ELM frequency), ELM energy loss and properties of the edge transport barrier. Inspired by the statistical description of a wide range of phenomena like fluid turbulence and image texture, and by earlier work in [1], in this work we take a probabilistic approach to study ELM phenomenology, in order to exploit the additional information provided by probability distributions compared to the mere averages. We investigate the distribution of the inter-ELM time  $\Delta t_{\text{ELM}}$ , under stationary plasma conditions in each pulse, in a database of several thousands of plasma pulses from the JET tokamak. Various plasma conditions between pulses, different wall materials (carbon wall and ITER-like wall) and ELM types (I, III and compound) are represented in the database. A wide variety of shapes of the ELM timing distributions is observed throughout the database, characterized by unimodal symmetric and skewed densities, but also multimodal distributions, which may point to different underlying physical mechanisms explaining the ELM dynamics. As a practical application, we consider discrimination between ELM types based on the distribution of  $\Delta t_{\text{ELM}}$ . While the dynamics of type I ELMs usually occurs on a longer time scale than that of type III ELMs, there are cases where the difference is much less clear, in particular with the ITER-like wall in JET, such that a quick and robust assessment of the ELM type would be useful. In this paper we employ a Weibull model for  $\Delta t_{\text{ELM}}$  in each pulse and we use the Rao geodesic distance based on the Fisher metric to discriminate between distributions on the corresponding probabilistic manifold. We show in particular that the Rao distance is more suitable as a distance measure compared to the (symmetrized) Kullback-Leibler divergence, either based on the Weibull model, or calculated by Monte Carlo integration using the individual samples without using an explicit model.

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\*See the author list of “X. Litaudon *et al.*, Nucl. Fusion **57** 102001, 2017.”

References:

- [1] A. Shabbir, G. Hornung, G. Verdoolaege, and JET Contributors, “A classification scheme for edge-localized modes based on their probability distributions,” *Rev. Sci. Instrum.* **87**, 11D404, 2016.